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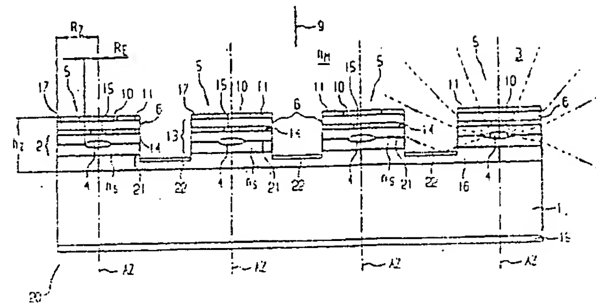
The following information has been taken from the documents submitted by the applicant.

AMb

An examination request under § 44 PatG [Patentgesetz; Patent Law] has been filed.

(54) Monolithic electroluminescent component and method of fabrication thereof

(57) A monolithic electroluminescent component, particularly an LED chip, wherein arranged on a substrate (1) is an active layer sequence (2) suitable for emitting electromagnetic radiation (3) when current flows through the component. The active layer sequence (2) comprises a plurality of emission zones (4) arranged side by side. Assigned to each of said emission zones (4) is a radiation-extracting element (5) through which electromagnetic radiation generated in the emission zone (4) concerned is extracted from the component.



Description

The invention relates to a monolithic electroluminescent component, particularly an LED chip, wherein arranged on a substrate is an active layer sequence suitable for emitting electromagnetic radiation when current flows through the component, disposed after the layer sequence in a radiation direction of the component is a radiation-extracting layer through which at least a portion of the electromagnetic radiation is extracted from the component, and wherein adjacent the radiation-extracting layer is a medium whose refractive index is smaller than the refractive index of the material of the radiation-extracting layer.

It further relates to a method of fabricating said component.

In conventional LED chips of this kind, the active layer ordinarily extends over the entire growth surface of the substrate, a bond pad is usually mounted on the front of the chip and full-area contact metallization is usually applied to the back of the substrate, and the intention is to have current spread through the chip over the entire active layer, insofar as possible. Known in this regard is, for example, an LED semiconductor chip in which a thick extraction layer, a so-called window layer, is arranged over the electroluminescent active layer and is designed to improve current spread and the extraction of light from the chip.

The object of the present invention is to develop a component of the aforesaid kind and a method of fabricating same with which the extraction of radiation is improved.

This object is achieved by means of a monolithic electroluminescent component having the features of Claim 1 and methods having the features of Claims 19, 20, 23, 24 or 25.

The main radiation direction of the component is to be understood herein as that direction in which most of the electromagnetic radiation generated in the component exits therefrom.

Advantageous improvements of the component according to the invention and of the methods are set forth in Dependent Claims 2 to 18 and 21 and 22.

It is provided according to the invention that the active layer grown on the substrate comprises a plurality of emission zones which are arranged side by side relative to the radiation direction and each of which has at least one electroluminescent pn junction, and in that each emission zone has assigned to it a separate optical radiation-extracting element by means of which the electromagnetic radiation generated in that emission zone is extracted from the component. The emission zones

preferably lie in a growth plane of the substrate. The radiation-extracting elements are preferably made of semiconductor material that is transparent to the radiation generated in the component.

A first particular advantage of this component is, therefore, that the relative sizes of the individual emission zones and their associated radiation-extracting elements and their arrangement with respect to one another can be intercoordinated so that a large proportion of the electromagnetic radiation generated in the emission zones is directed at the radiation-extracting element in such a way that it is extracted from the chip. Regions of the active layer that are situated in an area unfavorable to the extraction of radiation can thus largely be eliminated.

The invention advantageously enables the thickness of the radiation-extracting layer constituted by the radiation-extracting elements to be substantially reduced. The smaller the cross section of the emission zones, the lower the minimum height of the radiation-extracting elements that is necessary for adequate extraction of radiation. In addition to shorter process durations, this also affords the particular advantage that extraction elements of high optical quality can be fabricated.

In a particularly preferred improvement of the component, each radiation-extracting element has the shape of a cylinder disposed perpendicularly to the growth plane. The material of the cylinder has a refractive index n_S that is greater than the refractive index n_M of the surrounding medium. Each of the emission zones is preferably arranged within the assigned cylinder. The particular advantage of this embodiment lies in its technical simplicity of fabrication. The cylinders are preferably made with conventional semiconductor mask technology.

Each of the emission zones preferably has a substantially circular cross-sectional area, disposed perpendicularly to the center axis of the associated cylinder, whose diameter is equal to or smaller than that of the associated cylinder. The center of the circular cross-sectional area of such an emission zone preferably lies substantially on the center axis of the associated cylinder.

Contact metallizations for supplying current to the emission zones are advantageously arranged on the top faces of the cylinders and are interconnected by electrically conductive webs. These contact metallizations are preferably annular in shape and extend along the edge of the top face of the cylinder, since no light extraction normally occurs there because of total reflection.

The height of the cylinder is preferably expressed by the relation $h_Z \cong 2 \cdot \tan\alpha_G \cdot (R_Z + R_E)$, where α_G represents the critical angle of total reflection at the transition from the cylinder to the medium surrounding it, R_Z the radius of the cylinder and R_E the radius of the associated emission zone. In a particularly preferred manner, the emission zones are disposed substantially at half the height h_Z of the associated cylinder. In this embodiment of the invention, the height of the cylinder is advantageously

selected so that substantially all the radiation that makes an angle with the jacket surface of the cylinder that is smaller than the critical angle of total reflection, and only this radiation, strikes the jacket surface of the cylinder concerned. The rest of the radiation strikes the top face of the cylinder, where it is either totally reflected or extracted, depending on the angle of incidence.

In a particularly preferred embodiment of the invention, the radius R_E of the circular emission zone is expressed by the relation $R_E \leq R_Z \cdot n_M/n_S$, where n_M is the refractive index of the surrounding medium, n_S the refractive index of the cylinder material and R_Z the radius of the cylinder concerned. The efficiency of the component can advantageously be optimized in this manner.

To further improve the extraction of radiation, in an advantageous improvement of the invention, on at least some of the cylinders the edge of the top face is beveled. This advantageously increases the solid angle from which radiation emanating from the emission zone will strike an interface between the radiation-extracting element and the medium surrounding it at an incident angle that is smaller than the critical angle of total reflection.

In a particularly preferred embodiment of the invention, it is provided that each radiation-extracting element has substantially the shape of a spherical segment and that each of the emission zones is at a distance from a vertex of its respective associated radiation-extracting element that is equal to or greater than the radius R_K of the spherical segment.

In this embodiment, the radiation characteristic of the component can be adjusted by varying the size of the emission zones and the distance of each emission zone from the aforesaid respective vertex. In this connection, in a particularly preferred manner, each of the emission zones has a cross-sectional area that is substantially circular perpendicularly to the radiation direction of the component.

The radius R_E of each emission zone is advantageously expressed by the relation $R_E \leq R_K \cdot n_M/n_S$, where R_K represents the radius of the associated spherical segment, n_M the refractive index of the surrounding medium and n_S the refractive index of the spherical-segment material. The center of the circular cross-sectional area of the emission zone advantageously lies substantially on the center axis of the associated spherical segment.

To obtain a good forward radiation characteristic for the component, the radius R_E of the emission zones is selected to be as small as possible, in particular smaller than $0.2 \cdot R_K$, and the distance of each emission zone from its respective vertex aforesaid is roughly the same $[R_K \cdot (1 + n_M/n_S)]$.

To achieve the best possible extraction of light with a simultaneous increase in efficiency over conventional components of this kind, the distance of each emission zone from the vertex of its respective associated spherical segment is roughly equal to the radius of the associated spherical segment, and the radius of the emission zone is less than or equal to $R_K \cdot n_M/n_S$.

In a further advantageous embodiment of the invention, each radiation-extracting element has substantially the shape of a pillar that is rhombic in cross section and in which the emission zone is arranged. This embodiment has the particular advantage that radiation that initially, on leaving the emission zone, strikes the interface between the radiation-extracting element and the surrounding medium at an incident angle that is greater than the critical angle of total reflection is extracted from the component after one or more reflections.

Further advantageous embodiments and improvements of the component will emerge from the exemplary embodiments described below in connection with Figs. 1 to 6.

Therein:

Fig. 1 is a schematic diagram of a section through a first exemplary embodiment,

Fig. 2 is a schematic diagram of a plan view from above of the exemplary embodiment according to Fig. 1,

Fig. 3 is a schematic diagram of a section through a second exemplary embodiment,

Fig. 4 is a schematic diagram of a cutaway portion of a plan view from above of the exemplary embodiment according to Fig. 3,

Fig. 5 is a schematic diagram of a section through a third exemplary embodiment and

Fig. 6 is a schematic diagram of a plan view from above of a fourth exemplary embodiment.

According to the exemplary embodiment of Figs. 1 and 2, in an LED chip **20**, a substrate 1, made, for example, of n-GaAs, is overlain by a Bragg reflector layer 16 on which is disposed a plurality of radiation-extracting elements **5** arranged side by side. Each of said radiation-extracting elements **5** has the shape of a cylinder **6** whose longitudinal center axis (AZ) is parallel to a main radiation direction **9** of the LED chip.

The main radiation direction **9** of the LED chip **20** is to be understood as that direction in which most the electromagnetic radiation **3** generated in the chip **20** exits therefrom.

In each cylinder **6**, the Bragg reflector layer **16** is overlain by an active layer sequence **2** comprising an emission zone **4**, followed, in the main radiation direction **9**, by a current aperture layer **14** comprising a current passage opening **15** and thereafter a contact layer **17**.

Active layer sequence **2** preferably comprises at least one electroluminescent pn junction **21** at about half the height h_Z of the cylinder **6**, and is made, for example, of InGaAlP.

Deposited with full area coverage on the side of substrate 1 facing away from active layer sequence **2** is a contact metallization **19**.

Current aperture layer **14** serves to confine the flow of current through active layer sequence **2** and thus through electroluminescent pn junction **21** to the region of the desired emission zone **4**. It is made of AlAs, for example, and except in current passage opening **15** is oxidized, i.e. electrically insulating, but transparent to the radiation generated in emission zone **4**.

Another way of realizing current aperture layer **14** is to deposit on active layer sequence **2** a layer sequence comprising a pn junction which is oppositely poled to the pn junction **21** of active layer sequence **2** and into which a window is etched in the region of the projected current passage opening **15**. The layer sequence with the oppositely to pn junction **21** [sic] is transparent to the radiation generated in the chip and is made, for example, of the same material as active layer sequence **2**.

A current aperture layer **14** can be arranged alternatively or additionally between active layer sequence **2** and substrate **1**.

The Bragg reflector layer **16** serves to reflect back in the forward direction radiation that emission zone **4** has emitted in the direction of substrate **1**. Such Bragg reflector layers are known per se and therefore will not be described in greater detail herein.

Contact layer **17** is also, for example, made of InGaAlP.

Disposed on the top face **10** of each cylinder **6** is a ring contact **11** that covers substantially only that area of the cylinder **6** through which little or no radiation would be extracted, owing to total reflection at the interface between the cylinder **6** and the surrounding medium. These ring contacts **11** are interconnected by electrically conductive webs **12**, and a central portion of the front side of the LED chip is covered with a bond pad **18** that is connected to the ring contacts **11** in an electrically conductive manner (cf. Fig. 2).

Between the cylinders **6**, Bragg reflector layer **16** is preferably provided with a reflective surface or layer **22** that reflects back in the radiation direction **9** at least a portion of a radiation emitted by cylinders **6** in the direction of substrate **1**.

The cylinders **6** are fabricated, for example, by the full-area epitaxial deposition of Bragg reflector layer **16**, active layer sequence **2**, current aperture layer **14** and contact layer **17** on substrate **1**, followed by photolithographic processing and etching.

Another method for producing the cylinders **6** is first to deposit on Bragg reflector layer **16** a mask layer into which circular windows are then etched by photolithographic processing and etching. Active layer sequence **2**, current aperture layer **14** and contact layer **17** are then precipitated epitaxially into these windows. The mask layer in this case is selected so that there occurs on it substantially no epitaxial precipitation of the material of active layer sequence **2**, current aperture layer **14** and contact layer **17**. The mask layer is removed, for example by etching, after the precipitation of the cylinders **6**.

To make the current passage opening **15** when an oxidizable layer is used for this purpose, after the production of the cylinders **6** this oxidizable layer is oxidized and thereby rendered electrically insulating by tempering in an oxygen-containing or humid atmosphere, from the outside to the inside, except in the desired current passage opening **15**.

To make current passage opening **15** when a pn junction that is poled oppositely to pn junction **21** of active layer sequence **2** is used for current aperture layer **14**, after the layer sequence for the oppositely poled pn junction has been grown, before the deposition of contact layer **17**, a window defining current passage opening **15** is etched in said layer sequence by photolithographic processing and etching.

In yet another embodiment, which does not require a current aperture layer **14**, the electroluminescent pn junction is not produced over the full area of the substrate, but is formed only locally in the regions of the projected emission zones **4**, for example by ion implantation in the active layer sequence **2**. To this end, a mask layer comprising windows for ion implantation is deposited on active layer sequence **2** once the latter has been grown.

The exemplary embodiment of Figs. 3 and 4 again concerns an LED chip **20** in which a Bragg reflector layer **16** is deposited on a substrate **1** made, for example, of n-GaAs. This Bragg reflector layer **16** is overlain by an active layer sequence **2** comprising at least one electroluminescent pn junction **21** in which a plurality of emission zones **4** is arranged.

Disposed after active layer sequence **2** in the main radiation direction **9** of the component is a current aperture layer **14** comprising a plurality of current passage openings **15**. Here again, the current passage openings **15** serve to confine the flow of current through active layer sequence **2**, and thus through electroluminescent pn junction **21**, to the region of the desired emission zones **4**.

A current aperture layer **14** of this kind can be arranged alternatively or additionally between active layer sequence **2** and substrate **1**.

In addition, disposed after each emission zone **4** in the main radiation direction **9** of the component is a radiation-extracting element **5** that has the shape of a spherical segment **7**, a hemisphere in this case. Deposited on current aperture layer **14** between the spherical segments **7** is an ohmic contact **23** that covers only the edges of the spherical segments **7**.

In a partial region of the front side of the chip that contains no spherical segments **7**, a bond pad **18** that is connected to ohmic contact **23** in an electrically conductive manner is realized on current aperture layer **14** (cf. Fig. 4).

Each of the emission zones **4** preferably has a cross-sectional area, disposed perpendicularly to a radiation direction of the component, that is substantially circular and has a radius R_E equal to or smaller than the radius R_K of the associated spherical segment 7.

The radius R_E of each emission zone 4 is expressed by the relation $R_E \le R_K \cdot n_M/n_S$, where R_K is the radius of the associated spherical segment 7, n_M the refractive index of the surrounding medium M, e.g. plastic, and n_S the refractive index of the spherical-segment material. The center of the circular cross-sectional area of emission zone 4 lies substantially on the center axis AK of the associated spherical segment 7.

The distance d of each emission zone 4 from the vertex S of its associated spherical segment 7 is preferably expressed by $R_K \le d \le R_K \cdot (1 + n_M n_S)$.

Current aperture layer 14 is made, for example, of oxidizable semiconductor material. This is oxidized, except in current passage openings 15, which define the size of the emission zones 4 in the active layer sequence 2, and is therefore electrically insulating but transparent to the radiation emitted by the emission zones 4.

Another way of realizing current aperture layer 14 is to overlay active layer sequence 2 with a layer sequence comprising a pn junction which is poled oppositely to pn junction 21 of active layer sequence 2 and in which windows are realized in the region of the projected current passage openings 15.

The spherical segments 7 are preferably made of a semiconductor material that is electrically conductive and is transparent to the electromagnetic radiation **3** emitted by the component. In the case of an active layer sequence **2** made of InGaAlP, spherical segments 7 made of conductively doped InGaAlP are suitable and are preferred.

In a first variant of the fabrication of a component according to the exemplary embodiment of Fig. 3, after the deposition of active layer sequence **2**, comprising, for example, an n-doped and a

p-doped InGaAlP layer, an oxidizable, conductively doped semiconductor layer, made for example of AlAs, is deposited. This is followed by the deposition of an electrically conductively doped radioparent semiconductor layer, in the present example a p-doped InGaAlP semiconductor layer. The spherical segments **7** are then realized in that layer by etching in such fashion that the oxidizable semiconductor layer is exposed between spherical segments **7**. In an oxidation process carried out in an oxygen-containing atmosphere, the oxidizable layer is then oxidized away from the outside to the inside except in the projected current passage openings **15**. Ohmic contact **23**, for example in the form of a known contact metallization, is then deposited and covers substantially only the edges of the spherical segments **7**.

In a second variant for fabricating a component according to the exemplary embodiment of Fig. 3, the deposition of active layer sequence **2**, which comprises for example an n-doped **26** and a p-doped InGaAlP layer **27**, is followed by the deposition thereon of a layer sequence comprising a pn junction poled oppositely to pn junction **21** of active layer sequence **2**. To this end, in the aforesaid exemplary case, a p- and then an n-doped InGaAlP layer are preferably deposited on the p-InGaAlP layer by epitaxial growth, preferably without interrupting the precipitation. Then, after photolithographic processing, the n-doped InGaAlP layer of the layer sequence comprising the oppositely poled pn junction is removed by etching in the region of the desired current passage opening. A p-InGaAlP layer having a thickness D is then grown on the bare p-InGaAlP layer and on the remaining n-InGaAlP layer. Thereafter, a plurality of hemispheres **7** is etched into this new layer in such a way that the n-InGaAlP layer is exposed between the hemispheres **7**. This is followed by the deposition of ohmic p-contact **23**, which covers substantially only the edges of the spheres. Bond pad **18** is deposited in the same manner as in the above-described first variant. Ohmic contact **23** and bond pad **18** can be deposited directly on the n-doped InGaAlP barrier layer. Interlayer connection can be prevented, if necessary, by placing an insulating oxide, an insulating nitride or a proton-implanted insulating layer under the bond pad.

The Bragg reflector layer **16** is optional and can be omitted both in the exemplary embodiment of Fig. 1 and in that of Figs. 3 and 5, or it can be replaced by a reflecting backside for the substrate **1** in cases where substrate **1** is transparent to the emitted electromagnetic radiation.

The exemplary embodiment of Fig. 5 differs from that of Fig. 3 basically in that conical frusta or polyhedra **24** are provided in place of the hemispheres **7** as the radiation-extracting elements **5**.

To produce the conical frusta or polyhedra **24**, in a method of the above-described second variant, the fabrication of current aperture layer **14** is followed by the deposition on its n-InGaAlP layer of an oxide mask **25** that is so structured and oriented as to spare an area around current passage opening **15** that substantially corresponds to the size of the bases of the projected conical frusta or polyhedra **24**. Then, through the use of suitable precipitation conditions, a p-InGaAlP layer is selectively deposited epitaxially on the bare spot of p-InGaAlP destined for current passage opening **15** and on the surface of the n-InGaAlP layer of current aperture layer **14** that is not covered by oxide mask **25**, which means that there is no epitaxial precipitation on the oxide mask. The growth conditions are selected so that the conical frusta or polyhedra **24** are formed. An ohmic p-contact **23** that covers substantially only the edges of the conical frusta or polyhedra **24** is then deposited on oxide mask **25** between said conical frusta or polyhedra **24**.

The exemplary embodiment of Fig. 6 differs from that of Fig. 1 basically in that in this case the radiation-extracting elements **5** each have substantially the shape of a pillar that is rhombic in cross section. The advantages of this shape, as set forth hereinabove in the general part of the description, are that radiation that initially, on leaving emission zone **4**, strikes the interface between radiation-extracting element **5** and the surrounding medium M at an incident angle that is greater than the critical angle of total reflection is ultimately extracted from the component after single or multiple total reflection.

Claims

1. A monolithic electroluminescent component, particularly an LED chip, wherein
- arranged on a substrate **(1)** is an active layer sequence **(2)** suitable for emitting electromagnetic radiation **(3)** when current flows through the component,
- arranged after said active layer sequence **(2)** in a radiation direction **(9)** of said component is a radiation-extracting layer **(13)** through which at least a portion of said electromagnetic radiation is extracted from said component, and wherein
- adjacent said radiation-extracting layer **(13)** is a medium whose refractive index **(n_M)** is smaller than the refractive index **(n_S)** of the material of said radiation-extracting layer **(13)**,

characterized in that

said active layer sequence (2) comprises a plurality of emission zones (4) arranged side by side relative to said radiation direction (9) and in that said radiation-extracting layer (13) comprises for each of said emission zones (4) a radiation-extracting element (5) assigned thereto, through which electromagnetic radiation generated in the associated emission zone (4) is extracted from said component.

2. The component as recited in claim 1, characterized in that said radiation-extracting elements (5) each have the shape of a cylinder (6) whose longitudinal center axis (AZ) is substantially parallel to said radiation direction (9) and in that said emission zones (4) is [sic] arranged, in the respective associated cylinder (6) or viewed in said radiation direction (9) of said component, before said respective associated cylinder (6) [clause sic].

3. The component as recited in claim 2, characterized in that said emission zones (4) each have a cross-sectional area, disposed perpendicularly to the center axis (AZ) of the associated cylinder (6), that is substantially circular and whose diameter is the same as or smaller than that of the associated cylinder (6).

4. The component as recited in claim 3, characterized in that the center point of the circular cross-sectional area of each emission zone **(4)** lies substantially on the center axis **(AZ)** of the associated cylinder **(6)**.

5. The component as recited in claim 3 or 4, characterized in that the size and shape of said emission zones **(4)** are defined in each case by a current aperture layer **(14)** comprising a current passage opening **(15)** that is smaller than the cross-sectional area of the associated cylinder **(5)**.

6. The component as recited in one of claims 3 to 5, characterized in that the height h_Z of each cylinder **(6)** is expressed by the relation:

$$h_Z \cong 2 \cdot \tan\alpha_G \cdot (R_Z + R_E)$$

wherein:

α_G is the critical angle of total reflection at the transition from said cylinder (6) to said surrounding medium **(M)**,

R_Z is the radius of said cylinder **(6)** and

R_E is the radius of said associated emission zone (4),

and in that said emission zone **(4)** is arranged at substantially half the height (h_Z) of said associated cylinder (6).

7. The component as recited in one of claims 3 to 6, characterized in that the following relation holds for each emission zone (4):

$$R_E \leq R_Z \cdot n_M / n_S$$

wherein:

R_E is the radius of said emission zone (4),

n_M is the refractive index of said surrounding medium **(M)**,

n_S is the refractive index of the cylinder material and

R_Z is the radius of said associated cylinder **(6)**.

8. The component as recited in one of claims 2 to 7, characterized in that provided on a top face **(10)** of each cylinder **(6)** is an annular contact metallization **(11)** that supplies current to the associated emission zones **(4)** and that extends along the edge of said top face, and

in that all said contact metallizations **(11)** are interconnected by electrically conductive webs **(12)**.

9. The component as recited in one of claims 2 to 8, characterized in that on at least some of the cylinders, the edge of said top face **(10)** is beveled **(6)**.

10. The component as recited in claim 1,

characterized in that

each radiation-extracting element (5) has substantially the shape of a spherical segment (7) and in that each of said emission zones (4) is at a distance (d) from a vertex (S) of the respective associated radiation-extracting element (5) that is equal to or greater than the radius (R_K) of said spherical segment (7).

11. The component as recited in claim 10, characterized in that each of said emission zones (4) has a cross-sectional area, disposed perpendicularly to a radiation direction of said component, that is substantially circular and has a radius (R_E) that is equal to or smaller than the radius (R_K) of the associated spherical segment (7).

12. The component as recited in claim 11, characterized in that the radius R_E of each emission zone (4) is expressed by the relation:

$$R_E \leq R_K \cdot n_M / n_S$$

wherein:

R_K is the radius of the associated spherical segment (7),

n_M is the refractive index of the surrounding medium **(M)** and

n_S is the refractive index of the material of the spherical segment

and in that the center **(ME)** of said circular cross-sectional area of said emission zone **(4)** lies substantially on the center axis **(AK)** of the associated spherical segment **(7)**.

13. The component as recited in one of claims 10 to 12, characterized in that the following relation holds for each emission zone (4):

$$R_K \leq d \leq R_K \cdot (1 + n_M/n_S)$$

wherein:

d is the distance of said emission zone (4) from the vertex (S) of said spherical segment (7).

14. The component as recited in one of claims 1 or 10 to 13, characterized in that said active layer sequence (2), comprising an electroluminescent layer, is deposited on said substrate (1) with full area coverage, in that said active layer sequence (2) is overlain by a current aperture layer (14) made of oxidizable semiconductor material, which, except in said current passage openings (15) that define the size of said emission zones (4) in said active layer sequence (2), is oxidized and is therefore electrically insulating, but transparent to the radiation emitted by said emission zones (4), and in that said current aperture layer (14) is overlain by a further semiconductor layer in which said radiation-extracting elements (5) are formed.

15. The component as recited in one of claims 1 or 10 to 13, characterized in that said active layer sequence (2), comprising an electroluminescent layer, is deposited on said substrate (1) with full area coverage, in that said active layer sequence (2) is overlain by a current aperture layer (14) which, except in said current passage openings (15) that define the size of said emission zones (4) in said active layer sequence (2), comprises a pn junction that is poled oppositely to the forward direction of said component, and in that said current aperture layer (14) is overlain by a further semiconductor layer in which said radiation-extracting elements (5) are formed.

16. The component as recited in claim 1, characterized in that each radiation-extracting element (5) has substantially the shape of a pillar (8) that is rhombic in cross section.

17. The component as recited in one of claims 1 to 16, characterized in that said radiation-extracting elements (5) are made substantially of semiconductor material that is transparent to the radiation emitted by said component, and are produced monolithically by conventional dry or wet chemical etching processes.

18. The component as recited in one of claims 2 to 9 or 16 or 17, characterized in that a surface of the component that is present between said radiation-extracting elements **(5)** is realized as reflective.

19. A method of fabricating a component according to one of claims 2 to 9, characterized in that said cylinder **(6)** is produced by the full-area epitaxial deposition of said active layer sequence **(2)**, a current aperture layer **(14)** and a contact layer **(17)** on said substrate **(1)** and subsequent photolithographic processing and etching.

20. A method of fabricating a component according to claims 2 to 9, characterized in that deposited on said substrate **(1)** first is a mask layer in which circular windows are then etched by photolithographic processing and etching,
in that said active layer sequence **(2)**, a current aperture layer **(14)** and a contact layer **(17)** are then precipitated epitaxially into each of the windows, said mask layer being selected so that there occurs on it substantially no epitaxial precipitation of the material of said active layer sequence **(2)**, said current aperture layer **(14)** and said contact layer **(17)**.

21. The method of fabricating a component as recited claim 19 or 20, characterized in that used as said current aperture layer **(14)** is an oxidizable layer which, after the production of said cylinders **(6)**, is oxidized and thereby rendered electrically insulating by tempering in an oxygen-containing atmosphere, from the outside to the inside, except in the desired current passage openings **(15)**.

22. The method of fabricating a component as recited in one of claims 19 and 20, characterized in that deposited on said active layer sequence **(2)** comprising the pn junction **(21)** is a pn junction which is poled oppositely to said pn junction **(21)** of said active layer sequence **(2)** and in which, in order to make said current passage opening **(15)**, before the deposition of said contact layer **(17)**, a window that defines said current passage opening **(15)** is etched by photolithographic processing and etching.

23. A method of fabricating a component according to one of claims 2 to 9, characterized in that said cylinders (6) are produced by the epitaxial deposition of said active layer sequence (2) with full area coverage, the production of said emission zones (4) in said active layer sequence (2) by ion implantation, the deposition of a contact layer (17) on said substrate (1) and subsequent photolithographic and etching operations.

24. A method of fabricating a component according to claim 14, characterized in that after the said active layer sequence (2) is deposited on said substrate (1), an oxidizable, conductively doped semiconductor layer is deposited, in that an electrically conductively doped, radioparent semiconductor layer is deposited thereon, in that spherical segments (7) are formed therein by etching in such manner that the oxidizable semiconductor layer is exposed between said spherical segments (7), and in that in an oxidation process in an oxygen-containing atmosphere the oxidizable layer is subsequently oxidized away, from the outside to the inside, except in said current passage openings (15).

25. The method of fabricating a component according to claim 1 and claim 14 or 15, characterized in that provided as said radiation-extracting elements (5) are conical frusta or polyhedra (24), which are made, after the production of said current aperture layer (14), by depositing thereon an oxide mask (25) that is so structured and oriented as to spare areas around said current passage openings (15) that substantially correspond to the size of the bases of the projected conical frusta or polyhedra (24), [and] in that thereafter said conical frusta or polyhedra (24) are selectively precipitated directly onto the area of said current aperture layer (14) not covered by said oxide mask (25).

Accompanied by 5 page(s) of drawings

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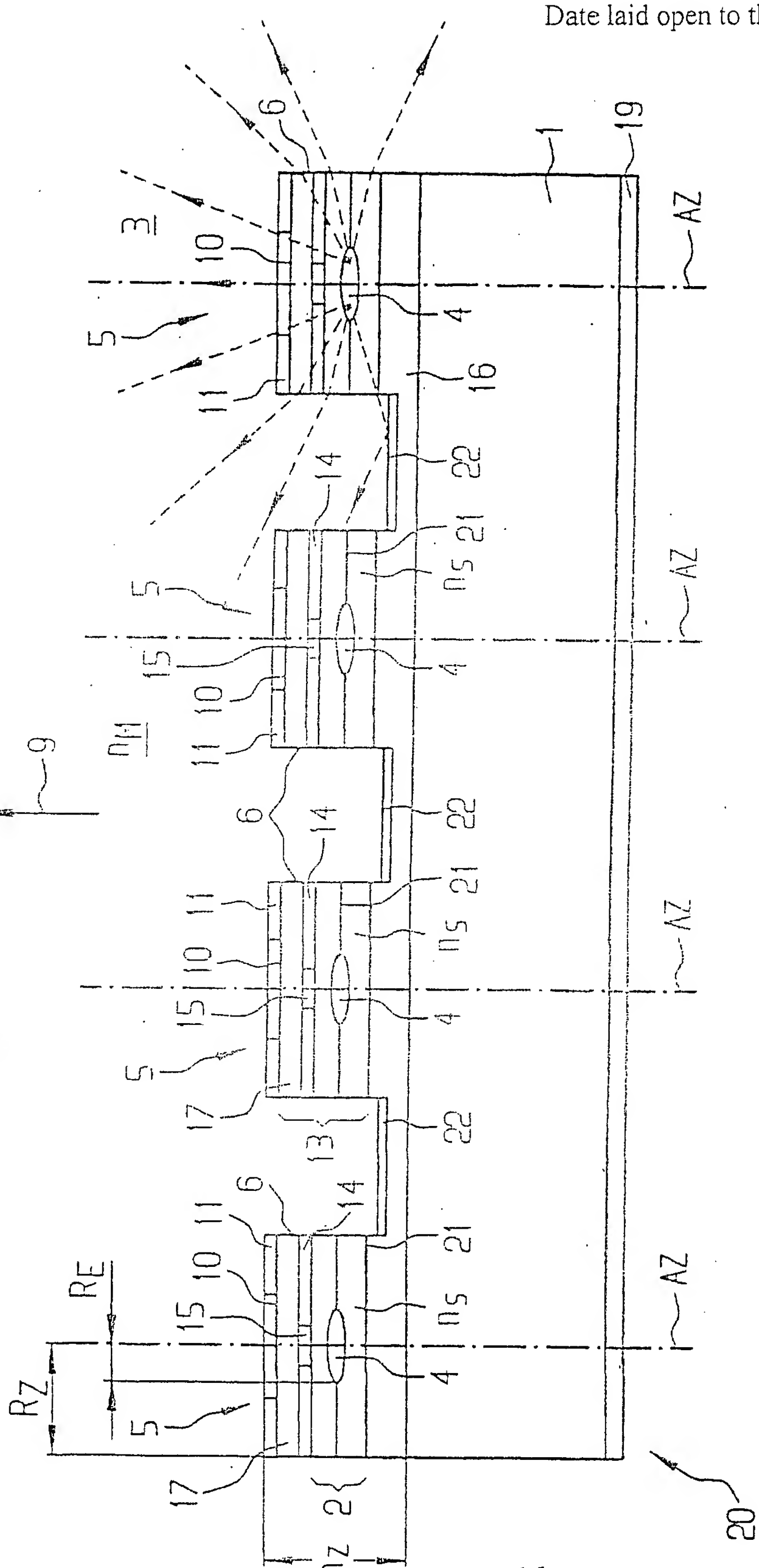


FIG 1

FIG 2

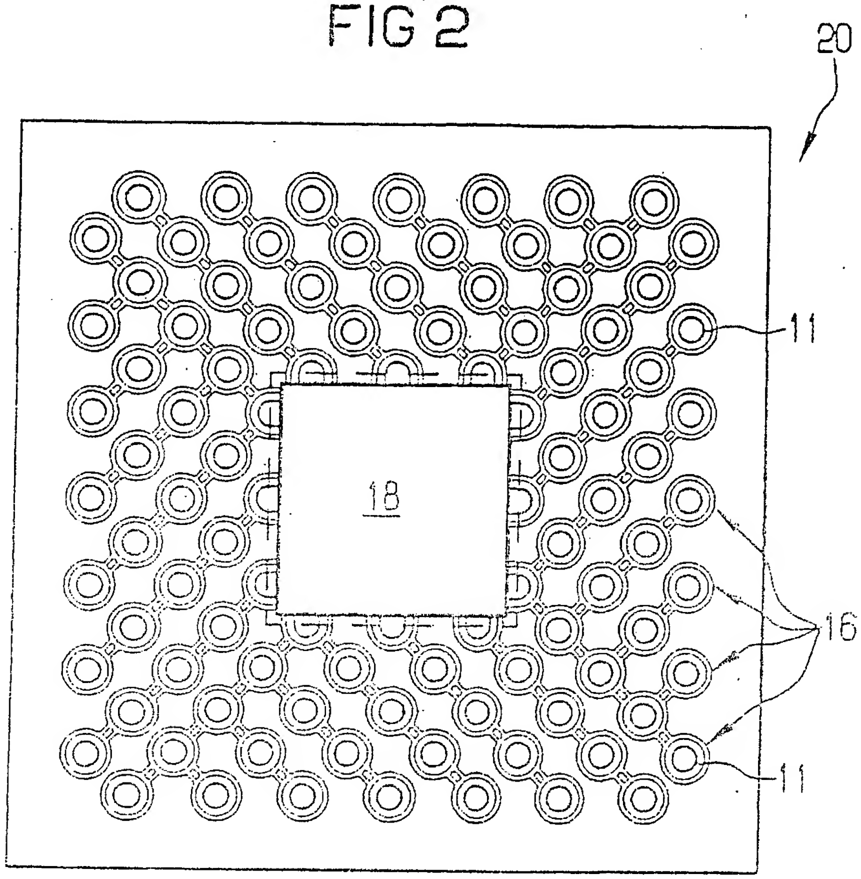
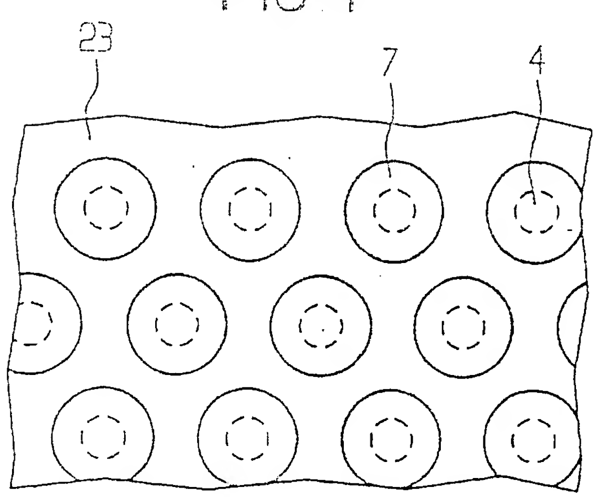


FIG 4



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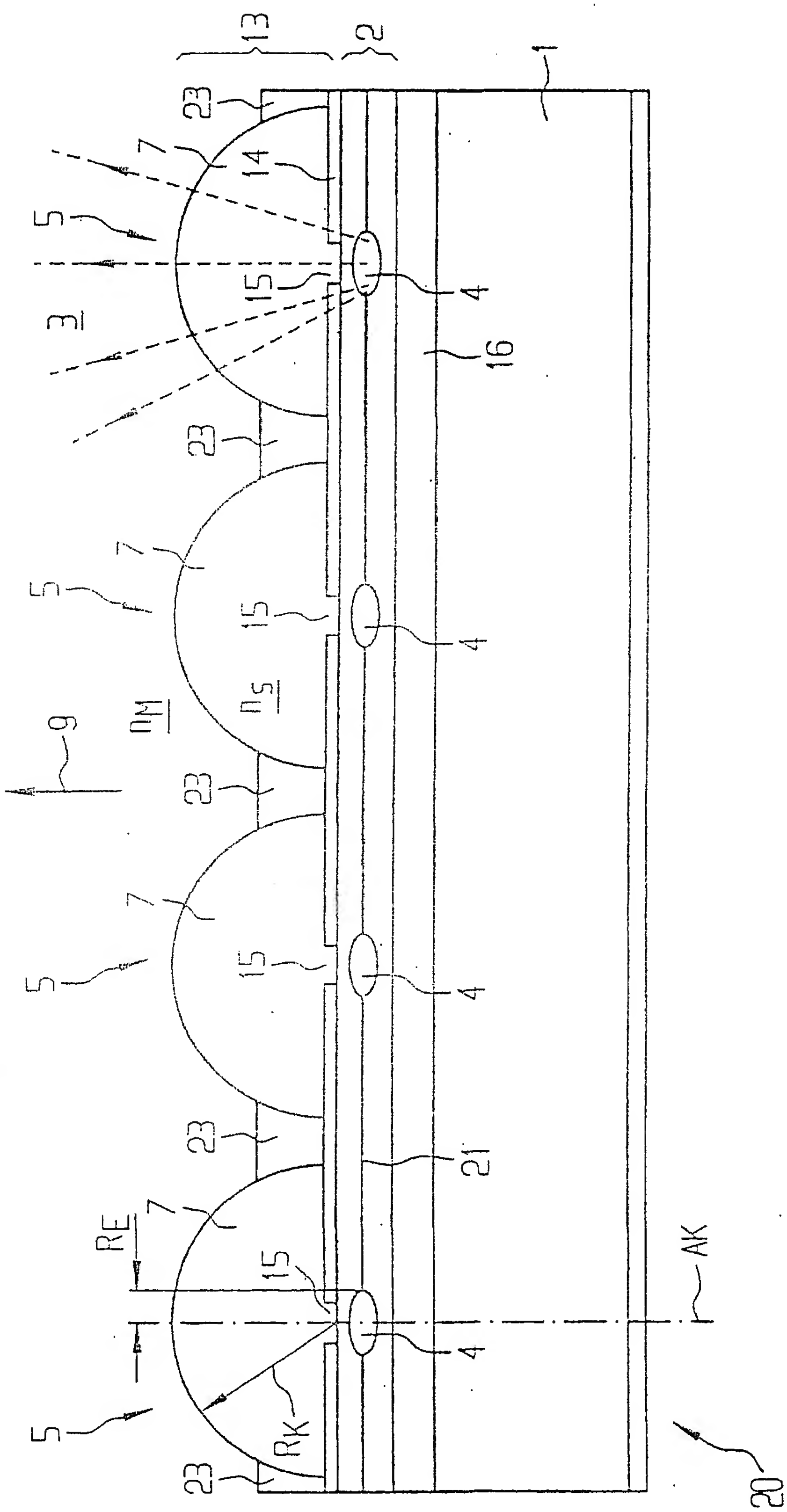

FIG 3

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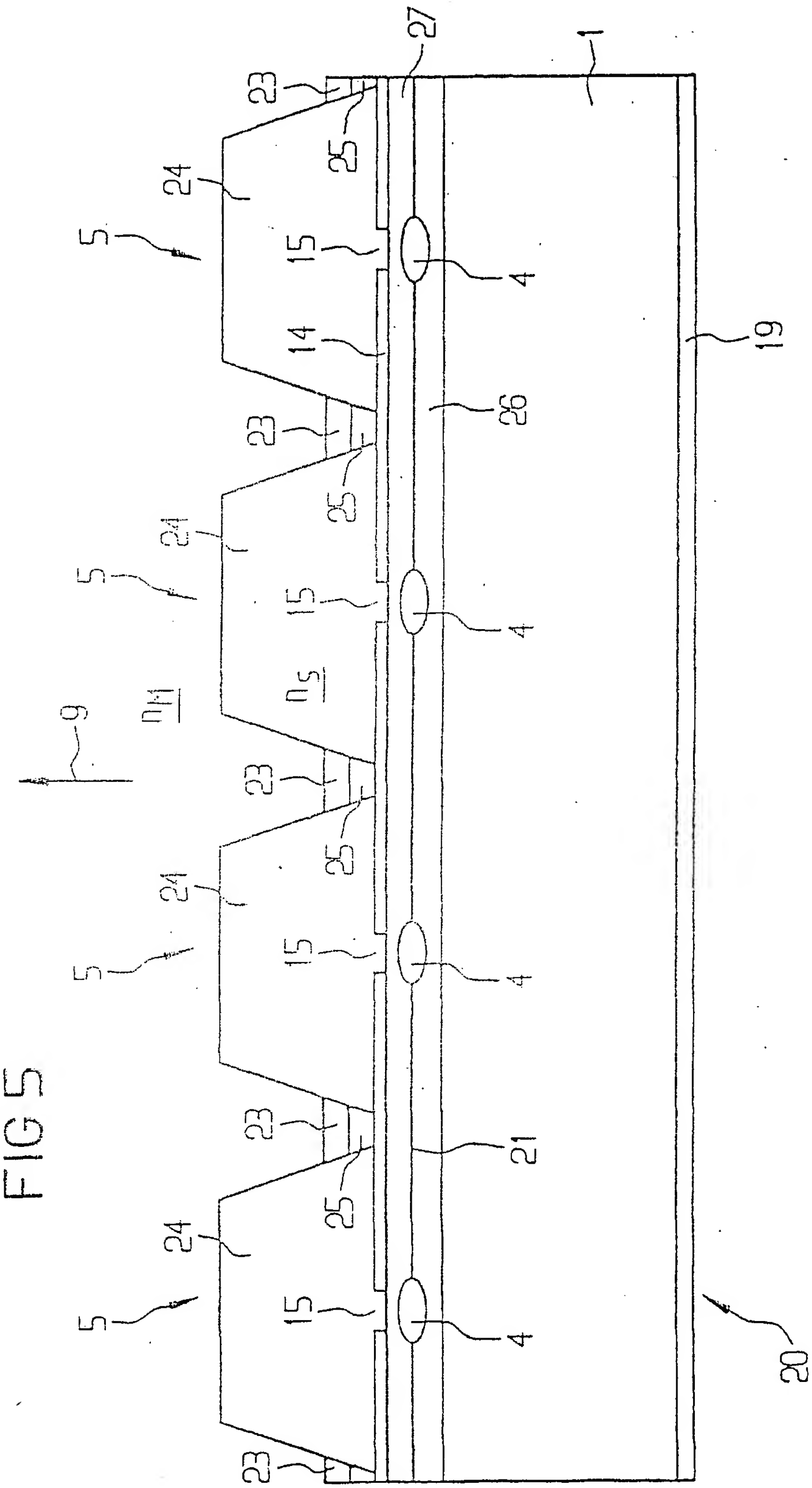

FIG 5

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FIG 6